PORTLAND HARBOR SUPERFUND SITE
ECOLOGICAL RISK ASSESSMENT:
SUPPLEMENTAL BENTHIC TOXICITY TESTING MEMORANDUM: UPSTREAM AMBIENT SAMPLING APPROACH AND ADDITIONAL SITE SAMPLING

DRAFT

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LIST OF ACRONYMS

CRD	Columbia River Datum
EPA	US Environmental Protection Agency
ISA	Initial Study Area
PAH	polycyclic aromatic hydrocarbon
RM	river mile
SVOC	semivolatile organic compounds
TOC	total organic carbon

1.0 INTRODUCTION

This supplemental memorandum describes the approach for identifying the number and locations for upstream ambient stations in the Willamette River for benthic sediment toxicity tests. In comments from the US Environmental Protection Agency (EPA) on the memorandum *Estimating Risks to Benthic Organisms using Sediment Toxicity Tests*, 10 – 20 ambient sampling locations were requested both down- and upstream of the Portland Harbor site from Sauvie Island to the Willamette Falls. According to EPA, the purpose of the samples is to "help with establishing hit/no-hit criteria, developing a predictive model and understand the inherent variability associated with the benthic toxicity testing." During further communication with EPA, the request for downstream ambient sampling locations was clarified (pers.comm. Lisa Saban with Eric Blischke 9/3/04). The agencies are requesting two additional sampling locations, downstream of the site, near Sauvie Island between river mile (RM) 2 and 3.

Both the upstream ambient samples and the two Sauvie Island sediment samples will be characterized by chemical analyses and two toxicity tests (28-day *Hyalella azteca* and 10-day *Chironomus tentans*). The resulting upstream ambient data will be used to generally represent toxicity of sediment upstream of major sources that may be associated with the Portland Harbor area, and will be used to represent relatively uncontaminated sediments in evaluating predictive relationships between toxicity and chemical conditions in the river. As described in Section 1.3 of the Programmatic Work Plan, and in Section 4.3.3 of the memorandum, *Estimating Risks to Benthic Organisms using Sediment Toxicity Tests,* the upstream ambient information will be used in the risk characterization of the benthic ecological risk assessment for the Portland Harbor Superfund Site. The Sauvie Island sample information will be included in the benthic predictive model for RM 2-3, downstream of the site.

2.0 IDENTIFICATION OF UPSTREAM AMBIENT SAMPLING LOCATIONS

This section describes the approach to identify the number and location of the proposed upstream ambient sampling locations. This section also includes a presentation of the historical chemical and toxicity data in the Willamette River and how those historical data were used in determining proposed sample locations.

2.1 APPROACH

The Willamette River is influenced by physical, chemical, and biological factors which vary spatially, potentially resulting in a range of benthic habitats. To adequately characterize the benthic habitat conditions in the Lower Willamette River (LWR), the habitat variables deemed most influential were used to create a matrix, with each cell representing a combination of habitat characteristics. Four variables were considered in selecting locations for collecting upstream samples: water depth relative to Columbia River Datum (CRD) as a measure of depth to sediment, grain size, flow rate, and total organic carbon (TOC). These variables typically play a role in defining benthic communities to some extent. Of these variables, three were selected to represent the potential range in the riverine habitats of interest:

- water depth,
- grain size, and
- flow rate.

TOC was also considered an important factor, but because TOC covaries to a large extent with grain size at the site, it was not incorporated in the matrix as a separate parameter. To attempt to capture the higher end of the TOC range, two additional samples will be collected in areas with finer grain size (see Section 2.4). Ranges for these four variables within the Portland Harbor site are as follows: water depth 0 to -45 ft CRD, grain size 0 to 98% fines, and TOC 0.04 to 12%, while flow rate ranges from quiescent areas such as Swan Island Lagoon to the main channel. While the freshwater toxicity tests being used to characterize Portland Harbor sediments are generally not considered to be sensitive to these variables (e.g., in particular the toxicity test responses are not considered to be greatly influenced by sediment grain size), it is important to capture the potential range of habitat conditions within the Willamette River to adequately characterize ambient conditions.

To place upstream ambient sampling locations in the different habitat types, a matrix-based table was constructed, displaying combinations of the primary variables listed above (grain size, flow rate, and water depth). Water depth was divided into tidally influenced areas ($\geq$ -10ft CRD) and deeper areas (< -10 ft CRD). Three different grain sizes were selected: coarse-grained (<20% fines), medium-grained (20-60% fines), and

fine-grained (>60%). Because the flow rate varies both daily and seasonally a simple approach was taken to capture the influence of flow rate by dividing the areas into channel and quiescent areas. Known sources of contaminants will be avoided when selecting specific sampling locations. Fourteen upstream ambient locations, 12 based on habitat variables presented in Table 2-1, and two additional samples in areas that have fine grain size (and likely higher TOC), will be characterized by chemical analyses and toxicity tests.

Table 2-1. Matrix table based on the three primary variables: depth, grain size, and flow rate.

DEPTH (FT CRD)	GRAIN SIZE (% FINES)	QUIESCENT	CHANNEL
≥ - 10	<20%	X	X
≥ - 10	20-60%	X	X
≥ - 10	>60%	X	X
< -10	<20%	X	X
< -10	20-60%	X	X
< -10	>60%	X	X

Candidate sampling locations were identified using information collected in previous investigations involving sediment toxicity testing (see Section 2.2), and other information on physical habitat characteristics. A reconnaissance survey will be performed prior to sampling to verify the applicability of the locations and to take depth and grain size measurements (using field techniques). The survey will also designate the proposed locations as channel or quiescent areas. Finally, the survey will confirm that no readily apparent source of contamination is present in the vicinity of the ambient sampling locations.

2.2 AVAILABLE HISTORICAL SEDIMENT CHEMISTRY AND TOXICITY DATA

Limited chemistry and toxicity data have been collected in the LWR upstream of the initial study area (ISA) boundary. These data come from studies that are evaluating sediment collected in the Portland Harbor and comparing them to sediment from "reference" areas assumed to be clean. In the Programmatic Work Plan (2004) the majority of historical bioassay studies from the Portland Harbor were evaluated for data quality and placed into one of two categories: Category 1 data were found to have acceptable data quality, whereas Category 2 data had an unknown, incomplete, or unsatisfactory data quality status. A total of 17 studies that included bioassay data have been conducted in the Portland Harbor. Twelve of these studies were placed in Category 1 (Table 2-2). The majority of the Category 1 studies used either sediments collected in the Columbia River as reference sediments or the negative control for the comparison. The data from the latest study by Hart Crowser (Hart Crowser 2002) has not gone

through the evaluation process and has not been classified as Category 1 or 2 data at this time.

Only two out of the 14 studies used sediments collected in the Willamette River as reference sediments, all of which were collected upstream of the Portland Harbor. These two studies are the Lower Willamette River Reference Area Study (Hart Crowser 2002) and the McCormick and Baxter Creosoting Company Sediment Remedial Design Phase 1 and 2 (Ecology and Environment 2001).

Table 2-2. Summary of toxicity studies in environmental investigations in the LWR

DATE	TITLE	TESTS	REFERENCE	DATA QUALITY CATEGORY [a]	REFERENCE SITES	COMMENT
April-02	Lower Willamette River Reference Area Study	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans* 28-day bioaccumulation *Lumbriculus variegates* and *Corbicula fluminea*	Hart Crowser (2002)	Not evaluated in the work plan	9 upstream reference sites evaluated; 3 selected for chemistry analyses and bioassay testing	Hardtack Island, Elk Rock Island, Cedar Island
Oct-01	McCormick & Baxter Creosoting Company Sediment Remedial Design Phase 1	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Ecology & Environment (2001)	1	1 upstream reference site	S of Cedar Island
Aug-01	Results of Sediment Sampling and Analysis, Cargill Elevator Terminal	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Harding ESE (2001)	1	0	Used negative control sediment
Nov 00 – Jan 01	Maul Foster & Alongi, Inc. Samples for toxicity testing, Zidell Waterfront Property, Portland OR	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Data transmittals from NAS 2000-2001	Not evaluated in the work plan	0	Used negative control sediment
Oct-00	McCormick & Baxter Creosoting Company Sediment Remedial Design Phase 2	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Ecology & Environment (2001)	1	4 upstream reference sites	N of Elk Rock Island, N and S of Hog Island, and S of Cedar Island
Nov-99	Willamette River Sediment Sampling Evaluation, Portland District	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	ACOE (1999)	1	1	Reference site in the Columbia River near mouth of the Willamette River

Table 2-2. Summary of toxicity studies in environmental investigations in the LWR

DATE	TITLE	TESTS	REFERENCE	DATA QUALITY CATEGORY [a]	REFERENCE SITES	COMMENT
Jan-99	January 1999 Sediment Sampling Results for TOSCO Terminal	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Exponent (1999)	1	1	Reference site in the Columbia River
Oct-98	Sediment Characterization Study, Marine Terminal 4, Berth 416, Port of Portland	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Hart Crowser (1999b)	1	2	Reference sites in the Columbia River near Willow Bar Island
Oct-98	Sediment Characterization Study, Marine Terminal 4, Berths 203-206, Port of Portland	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Hart Crowser (1999c)	1	2	Reference sites in the Columbia River near Willow Bar Island
Oct-98 Dec-98	Remedial Investigation Report, Terminal 4, Slip 3 Sediments, Port of Portland (Phase 1 & 2)	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans*	Hart Crowser (1999a)	1	2	Reference sites in the Columbia River near Willow Bar Island
Apr-98	Portland Shipyard Sediment Investigation	10-day amphipod *Hyalella azteca* midge mortality and growth *Chironomus tentans* Microtox porewater	SEA (1998)	1, except 25 samples with Microtox holding time exceedances, which are category 2.	3	Reference sites in the Columbia River downstream of Willamette River
Jan-98	Willamette River Data	10-day amphipod *Hyalella azteca*	Dames & Moore (1998)	1	0	Used negative control sediment
Dec-97	Portland Shipyard Sediment Environmental Audit	10-day amphipod *Hyalella azteca*	Dames & Moore (1997)	1	0	Used negative control sediment

Table 2-2. Summary of toxicity studies in environmental investigations in the LWR

DATE	TITLE	TESTS	REFERENCE	DATA QUALITY CATEGORY [a]	REFERENCE SITES	COMMENT
May-94	Dredging Study Marine Terminal (Terminal 2, Berth 203)	10-day amphipod *Hyalella azteca* 48-hr mortality *Daphnia magna*	ACOE 1994	1	0	Used negative control sediment
Jan-92	McCormick & Baxter Creosoting Company Sediment Remedial Investigation Phase 2	10-day Amphipod *Hyalella azteca* Microtox porewater	PTI (1992)	2		Not evaluated due to data quality
Dec-91	Port of Portland Dry Dock 4	10-day amphipod *Hyalella azteca* 48-hr mortality *Daphnia magna* 96-hr mortality *Daphnia magna* rainbow trout mortality	ACOE 1991	2		Not evaluated due to data quality
Sep-90	McCormick & Baxter Creosoting Company Sediment Remedial Investigation Phase 1	10-day amphipod *Hyalella azteca*	PTI (1992)	2		Not evaluated due to data quality

[a] Bioassay data quality were evaluated based on validation guidelines and performance criteria from PSEP (PTI 1989). See Section 4 and Table 4-8 in Programmatic Work Plan and Appendix F for additional details.

The Hart Crowser study (Hart Crowser 2002) conducted a search for reference sediments in a two-phase approach. In the first phase nine upstream sites were selected with three different grain sizes. Fine-grained samples were HC-3 (60.9% fines), HC-4 (69.3% fines), and HC-8 (64.9% fines); medium-grained samples were HC-5 (25.1% fines), HC-9 (43.4% fines), and HC-10 (59.7% fines); and coarse-grained samples were HC-1 (5% fines), HC-2 (9.8% fines), and HC-7 (4% fines). The sediment samples were analyzed for pesticides, PCBs, total volatile solids, total solids, and TPH (gasoline, diesel, and residual range organics). For complete chemistry data see Table 2-3 attached to this memorandum. The locations of the nine upstream sites are shown in Figure 2-1. Three of the nine sediments were selected as reference sediments based on a decision matrix using the following criteria: analytical chemistry, stability of location, and grain size match. The selected locations, HC-2 (9.8% fines), HC-8 (64.9% fines), and HC-10 (59.7% fines), were used as reference sediments in toxicity tests with 10-day *Hyalella azteca* and 10-day *Chironomus tentans* and bioaccumulation tests with 28-day *Lumbriculus variegates* and *Corbicula fluminea*. Comprehensive chemical analyses were conducted at each station. For complete chemistry data for the three reference sites see Table 2-4 attached to this memorandum.

All three sediment samples met the performance standards for reference sediments. There was no evidence that exposure to these sediments had any adverse effects on amphipod survival or midge growth and survival (Table 2-5).

Table 2-5. Amphipod survival and midge growth and survival in historical reference sediments (Hart Crowser 2002)

STATION	% SURVIVAL *H. AZTECA*	% SURVIVAL *C. TENTANS*	MEAN INDIVIDUAL BIOMASS *C. TENTANS* (mg)
HC-2	92.5	86.2	2.42
HC-8	93.7	92.5	0.28
HC-10	93.7	83.7	0.46

The study by Ecology and Environment (Ecology and Environment 2001) collected sediments upstream of Portland Harbor in 1999 and 2001. In 1999 sediments were collected at four sites and analyzed for grain size, arsenic, and semivolatile organic compounds (SVOCs) including 17 polycyclic aromatic hydrocarbons (PAHs) and pentachlorophenol. In 2001 sediment was collected at one site and analyzed for grain size and SVOCs, including 17 PAHs and pentachlorophenol. The five selected sites were used as reference sediments in toxicity tests with 10-day *Hyalella azteca* and 10-day *Chironomus tentans.* The site locations are shown in Figure 2-1 and the results from the chemical analyses and toxicity testing are summarized in Table 2-6. The bioassay data were qualified as estimated quantities because the sediment samples when arrived at the laboratory had a temperature ranging from 7°C to 14°C exceeding the recommended temperature of 4°C ± 2°C.

Table 2-6. Co-located chemistry and toxicity data in historical reference sediments

STATION	PAHs (ug/kg)	TOTAL PAHs (ug/kg)	ARSENIC (ug/kg)	% SURVIVAL *C. TENTANS*	MEAN INDIVIDUAL BIOMASS (mg) *C. TENTANS*	% SURVIVAL *H. AZTECA*
SED99-40	53	91	4,100	62.5	1.20	97.5
SED99-41	ND	ND	3,300	76.3	1.28	91.3
SED99-42	137	376	3,500	68.8	1.19	98.8
SED99-43	ND	ND	3,000	85.0	1.56	97.5
SED01-30	ND	ND	NA	68.8	1.59	90.0

2.3 USE OF HISTORICAL SEDIMENT CHEMISTRY AND TOXICITY DATA

The historical data were used to assist in the identification of sample locations. The two historical toxicity studies were conducted using the 10-day *Chironomus* and the 10-day *Hyalella* tests. Because the exposure duration for the *Hyalella* test in the Portland Harbor RI/FS is different from the historical test duration (28 days vs 10 days, respectively) the data from the historical studies may be useful in identifying areas that may have lower toxicity, but are not appropriate for comparison to Portland Harbor toxicity test results because different exposure durations were used for one test. However, the available physical habitat data on the three primary variables collected during the two historical studies (Table 2-7) were useful in guiding the selection process for the upstream ambient locations. TOC values were only available for HC-2, HC-8, and HC-10, and ranged from 0.42 to 1.77%. It is doubtful that locations with high TOC will be found upstream since higher range TOC concentrations are generally associated with sources (e.g., outfalls) and we are avoiding sources in characterizing the upstream ambient locations.

Table 2-7. Depth, grain size, and habitat description from the upstream historical sites.

STATION	ELEVATION (FT CRD)	GRAIN SIZE (% FINES)	QUIESCENT	CHANNEL
HC-1	-5.3	5.0		X
HC-2	-5.9	6.1		X
HC-3	-10.3	60.9		X
HC-4	-24	69.3		X
HC-5	-25.5	25.1		X
HC-7	-29.5	4.0		X
HC-8	-6.5	66.3		X
HC-9	-6.5	43.4		X
HC-10	-11.8	52.8		X
SED99-40	> -10 (depth 8.5 ft)	2.42		X
SED99-41	> -10 (depth 3.5 ft)	0.28		X
SED99-42	< -10 (depth 9.2ft)	0.46	X	
SED99-43	> -10 (depth 5.1 ft)	1.05	X	
SED01-30	NA (> -10 ft CRD)	21.0	X	

NA - data not available but x,y coordinate the same as for SED99-43

The historical site locations met the specified conditions for several of the key variables outlined in Section 2.1. Table 2-8 presents the historic sample locations that will also be used as sampling locations for the present study. The historical reference site HC-2 will be used to guide the placement of a shallow, coarse-grained sampling location in the channel because it is the most recent sampling effort. Historical reference sites SED99-43 and SED01-30 were collected at the same location (same coordinates) but had different grain sizes. The data from SED01-30 will be used to guide the placement of a sampling location because it is the most recent data. The remaining areas, marked with an "X" in Table 2-8 and presented in Figure 2-2, are based on an initial review of Willamette River conditions and will be finalized following the site reconnaissance survey.

Table 2-8. Applicability of Historical Sampling Locations to Upstream Ambient Criteria

ELEVATION (FT CRD)	GRAIN SIZE (% FINES)	QUIESCENT	CHANNEL
≥ - 10	<20%	SED99-43	HC-2 SED99-40/41
≥ - 10	20-60%	SED01-30	X
≥ - 10	>60%	HC-8	X
< -10	<20%	SED99-42	X
< -10	20-60%	X	HC-10
< -10	>60%	X	HC-4

2.4 PROPOSED UPSTREAM AMBIENT LOCATIONS

Fourteen upstream ambient stations are proposed for sediment collection. Two benthic sediment toxicity tests (the same toxicity tests as used in the RI/FS Site analysis) and co-located chemical analysis (the same suite as in the RI/FS Site analysis) will be conducted at each location. Twelve of the fourteen locations will be located based on the habitat matrix table (see Table 2-1) presented in Section 2.1. Table 2-9 and Figure 2-2 present the proposed upstream ambient sample locations. In addition, two locations that may be representative of higher TOC (as identified by evaluating grain size during the field reconnaissance survey) will be sampled. The locations of the 12 upstream ambient sampling areas in the Willamette River are based on information from the bathymetric survey by David Evans and Associates (2003) and maps by NOAA (1984).

The final determination of all sampling locations will be based on preliminary depth and grain size measurements taken during the reconnaissance survey. The proposed locations have been placed throughout the river from RM 16 to RM 25 including areas where extensive chemical analyses and toxicity testing were not performed in the two historical studies.

Table 2-9 Proposed upstream ambient sampling locations

ELEVATION (FT CRD)	GRAIN SIZE (% FINES)	QUIESCENT[a]	CHANNEL[a]
≥ - 10	<20%	LWG-1-Q	LWG-2-C (HC-2)
≥ - 10	20-60%	LWG-11-Q (SED01-30)	LWG-5-C
≥ - 10	>60%	LWG-4-Q (HC-8)	LWG-7-C
< -10	<20%	LWG-9-Q (SED99-42)	LWG-12-C
< -10	20-60%	LWG-6-Q	LWG-10-C (HC-10)
< -10	>60%	LWG-8-Q[b]	LWG-3-C (HC-4)

[a] For proposed ambient sample locations, "Q" and "C" in the sample ID refer to "quiescent" and "channel" locations, respectively

[b] Two locations (LWG-8a-Q and LWG-8b-Q) will be visited during the reconnaissance survey and the most suitable location will be selected for chemistry and toxicity testing analyses

2.5 USE OF UPSTREAM AMBIENT DATA

The upstream ambient information will be used, consistent with EPA guidelines (EPA 2002), in the risk characterization of the benthic ecological risk assessment. This approach includes a qualitative discussion of upstream ambient contribution to the conditions in the ISA. The data cannot be used as reference data in the evaluation of the toxicity tests results because toxicity testing of the upstream ambient sediments was not done concurrently with the toxicity testing of the sediments collected in the ISA. To function as reference sediments the upstream ambient sediments should have been included in each batch of the 219 sediment samples collected in the ISA which was tested with the 10-day *Chironomus* and the 28-day *Hyalella* test.

3.0 PROPOSED ADDITIONAL SITE LOCATIONS

EPA has requested additional toxicity tests (and co-located chemistry) downstream of the ISA, between RM 2-3 on Sauvie Island. These samples are added to the sampling program to provide preliminary information on the toxicity of the sediments downstream downstream of Multnomah channel. Figure 2-3 presents Sauvie Island sample locations. Both locations are on the western side of the river and neither is near a known source of contamination from upland areas.

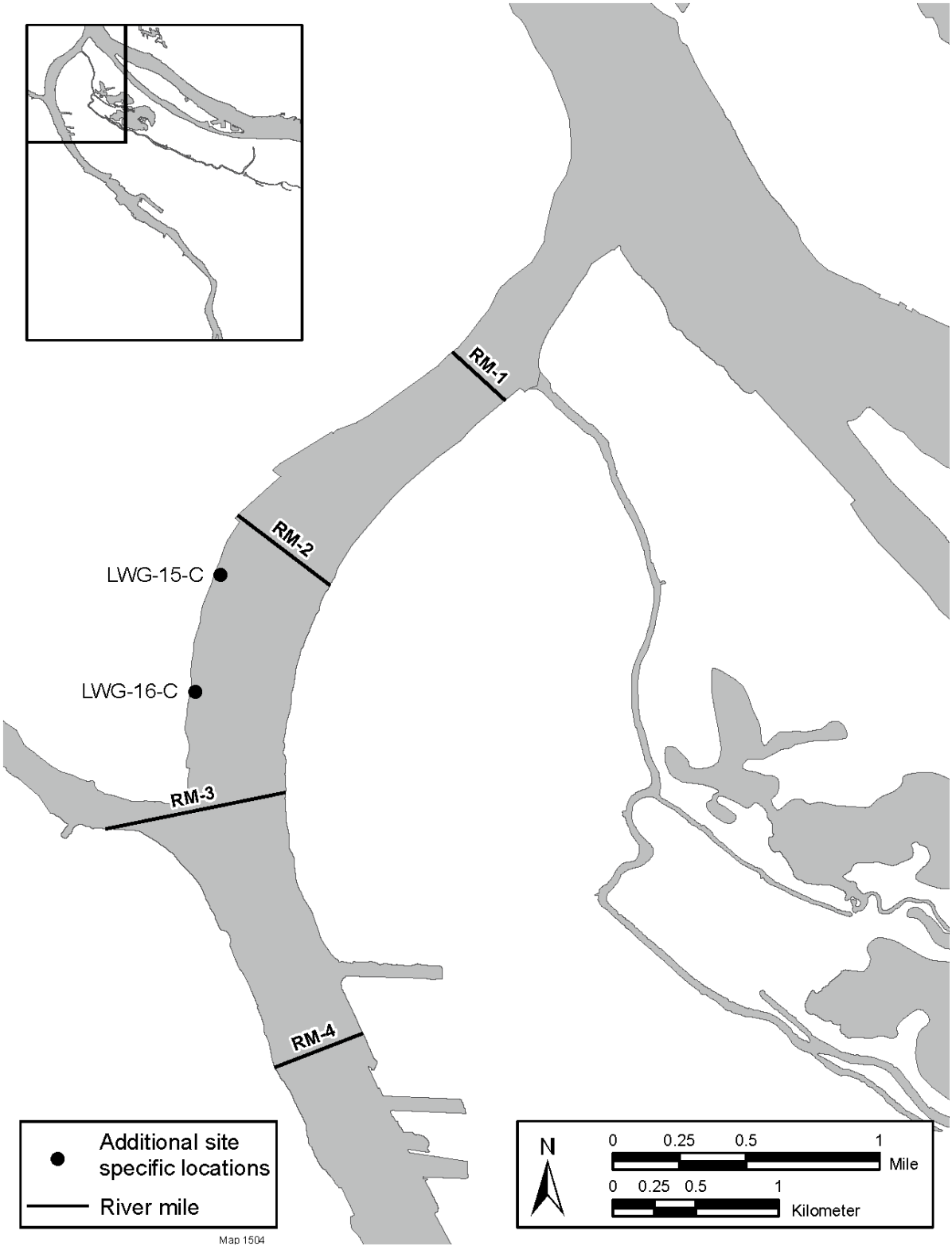

Figure 3-1. Additional site-specific sampling location on Sauvie Island.

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Table 2-3. Analytical results for Phase I sediment samples, Lower Willamette River Reference Area Study

Sample ID	**HC-1**		**HC-2**		**HC-3**		**HC-4**		**HC-5**		**HC-7**		**HC-8**		**HC-9**	**HC-10**
Depth ft (CRD)	-5.3		-16.3		-10.3		-2.4		-25.5		-29.5		-5.8		-6.5	-10.8
Conventionals (percent)																
Total volatile solids in %	3.35		3.97		6.03		7.11		4.27		2.35		7.23		6.5	6.65
Total solids in %	73.4		70.7		57.7		52.1		66.9		77.9		54.1		59.3	50.9
TPH (mg/kg)																
Gasoline range organics	14	U	14	U	33	U	37	U	28	U	13	U	35	U	28 U	34 U
Diesel range organics	14	U	14	U	34	Z	56	Z	28	U	13	U	39	Z	28 U	38 Z
Residual range organics	34	U	35	U	190	Z	290	Z	72	Z	32	U	230	Z	160 Z	200 Z
Pesticides (µg/kg																
Alpha-BHC	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Beta-BHC	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Gamma-BHC (Lindane)	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Delta-BHC	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Heptachlor	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Aldrin	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Heptachlor epoxide	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Gamma-chlordane	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Endosulfan I	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Alpha-chlordane	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Dieldrin	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
4,4'-DDE	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Endrin	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Endosulfan II	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
4,4'-DDD	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Endrin aldehyde	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Endosulfan sulfate	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
4,4'-DDT	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Endrin ketone	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U

Sample ID	**HC-1**		**HC-2**		**HC-3**		**HC-4**		**HC-5**		**HC-7**		**HC-8**		**HC-9**	**HC-10**
Methoxychlor	1.4	U	1.5	U	1.8	U	2.0	U	1.5	U	1.3	U	1.9	U	1.7 U	2.0 U
Toxaphene	6.9	U	71	U	87	U	96	U	75	U	65	U	93	U	85 U	98 U
PCBs (µg/kg)																
Aroclor 1016	14	U	15	U	18	U	20	U	15	U	13	U	19	U	17 U	20 U
Aroclor 1221	28	U	29	U	35	U	39	U	30	U	26	U	37	U	34 U	40 U
Aroclor 1232	14	U	15	U	18	U	20	U	15	U	13	U	19	U	17 U	20 U
Aroclor 1242	14	U	15	U	18	U	20	U	15	U	13	U	19	U	17 U	20 U
Aroclor 1248	14	U	15	U	18	U	20	U	15	U	13	U	19	U	17 U	20 U
Aroclor 1254	14	U	15	U	18	U	20	U	15	U	13	U	19	U	17 U	20 U
Aroclor 1260	14	U	15	U	18	U	20	U	15	U	13	U	19	U	17 U	20 U
Total PCBs	28	U	29	U	35	U	39	U	30	U	26	U	37	U	34 U	40 U

Source: Hart Crowser (2002)
U - Not detected at the indicated method reporting limits (MRL).
Z - The chromatographic fingerprint does not resemble a petroleum product (most likely a non-polar biogenic oil).

Table 2-4. Analytical results of Phase II sediment samples, Lower Willamette River Reference Area Study (Hart Crowser 2002)

SAMPLE-ID		HC-2	HC-8	HC-10
LAB-ID	DMEF	K2106748-001	K2106748-002	K2106748-003
SEDIMENT TYPE		COARSE-GRAINED	FINE-GRAINED	MEDIUM-GRAINED
SAMPLING DATE	SL	9/17/2001	9/17/2001	9/17/2001
Conventionals (percent)				
Carbon, total organic (TOC)		0.42	1.77	1.3
Solids, total volatile		2.62	6.16	5
Metals (mg/kg)				
Antimony, total	150	0.47 J	0.06 J	0.05 J
Arsenic, total	57	2.7	4.3	3.3
Cadmium, total	5.1	0.07	0.18	0.11
Chromium, total		16.8	40.5	29.4
Copper, total	390	15.4	50.9	34.1
Lead, total	450	5.24	12.6	9.21
Mercury, total	0.41	0.02	0.05	0.04
Nickel, total	140	18.5	35.7	27.2
Silver, total	6.1	0.1	0.22	0.15
Zinc, total	410	49.7	96.8	72.7
Organometallics (µg/L)				
Tetra-n-butyltin		0.072 U	0.05 U	0.05 U
Tri-n-butyltin (TBT)	0.15	0.07	0.07	0.064
Di-n-butyltin		0.037 J	0.035 J	0.017 J
n-Butyltin		0.072 U	0.05 U	0.05 U
LPAHs in µg/kg				
Acenaphthene	500	16 U	21 U	19 U
Acenaphthylene	560	3.2 J	4.5 J	3.5 J
Anthracene	960	16 U	21 U	5 J
Fluorene	540	16 U	21 U	19 U
Naphthalene	2100	3.3 J	7.8 J	6.1 J
Phenanthrene	1500	4.3 J	11 J	14 J

SAMPLE-ID		HC-2	HC-8	HC-10
LAB-ID	DMEF	K2106748-001	K2106748-002	K2106748-003
SEDIMENT TYPE		COARSE-GRAINED	FINE-GRAINED	MEDIUM-GRAINED
SAMPLING DATE	SL	9/17/2001	9/17/2001	9/17/2001
Total LPAHs	5200	10.8 J	23.3 J	28.6 J
HPAHs (µg/kg)				
Benz(a)anthracene	1300	4.8 J	8.1 J	13 J
Benzo(a)pyrene	1600	13 J	8.8 J	13 J
Benzo(b)fluoranthene		6.6 J	11 J	14 J
Benzo(g,h,i)perylene	670	45	9.6 J	14 J
Benzo(k)fluoranthene		5 J	4.4 J	5.2 J
Chrysene	1400	5.1 J	9.5 J	13 J
Dibenz(a,h)anthracene	230	16 U	21 U	19 U
Fluoranthene	1700	5.6 J	18 J	21
Indeno(1,2,3-cd)pyrene	600	12 J	8.2 J	8 J
Pyrene	2600	10 J	19 J	30
Total benzofluoranthenes	3200	11.7 J	15.4 J	19.2 J
Total HPAHs	12000	107.1	96.6 J	131.2
Phenols (µg/kg)				
2,4-Dimethylphenol	29	76 U	110 U	94 U
2-Methylphenol	63	16 U	21 U	19 U
4-Methylphenol	670	16 U	11 J	7.3 J
Pentachlorophenol (PCP)	400	150 U	210 U	190 U
Phenol	420	46 U	63 U	11 J
Phthalates(µg/kg)				
Bis(2-ethylhexyl) phthalate	8300	310 U	420 U	380 U
Butyl benzyl phthalate	970	16 U	21 U	19 U
Di-n-butyl phthalate	5100	16 U	9 J	6.5 J
Di-n-octyl phthalate	6200	16 U	21 U	19 U
Diethyl phthalate	1200	16 U	21 U	19 U
Dimethyl phthalate	1400	16 U	21 U	19 U
Semivolatiles (µg/kg)				

SAMPLE-ID		HC-2	HC-8	HC-10
LAB-ID	DMEF	K2106748-001	K2106748-002	K2106748-003
SEDIMENT TYPE		COARSE-GRAINED	FINE-GRAINED	MEDIUM-GRAINED
SAMPLING DATE	SL	9/17/2001	9/17/2001	9/17/2001
Benzoic acid	650	310 U	64 J	35 J
Benzyl alcohol	57	16 U	21 U	19 U
Dibenzofuran	540	16 U	21 U	19 U
Hexachlorobenzene	22	16 U	21 U	19 U
Hexachlorobutadiene	29	16 U	21 U	19 U
N-Nitrosodiphenylamine	28	16 U	21 U	19 U
Volatiles (µg/kg				
1,2-Dichlorobenzene	35	16 U	21 U	19 U
1,3-Dichlorobenzene	170	16 U	21 U	19 U
1,4-Dichlorobenzene	110	16 U	21 U	19 U
Pesticide/PCBs (µg/kg				
4,4'-DDD		1.6 U	0.99 JP	0.77 J
4,4'-DDE		1.6 U	0.76 J	0.8 J
4,4'-DDT		0.73 JP	1.4 JP	13
Total DDT	6.9	0.73 JP	3.15 J	**14.57**
Aldrin	10	1.6 U	2.1 U	1.9 U
Aroclor 1016		16 U	21 U	19 U
Aroclor 1221		31 U	42 U	38 U
Aroclor 1232		16 U	21 U	19 U
Aroclor 1242		16 U	21 U	19 U
Aroclor 1248		16 U	21 U	19 U
Aroclor 1254		16 U	21 U	19 U
Aroclor 1260		16 U	21 U	19 U
Total PCBs	130	16 U	21 U	19 U
Chlordane	10			
Dieldrin	10	1.6 U	2.1 U	1.9 U
Endosulfan I		1.6 U	2.1 U	1.9 U
Endosulfan II		1.6 U	2.1 U	1.9 U

SAMPLE-ID		HC-2	HC-8	HC-10
LAB-ID	DMEF	K2106748-001	K2106748-002	K2106748-003
SEDIMENT TYPE		COARSE-GRAINED	FINE-GRAINED	MEDIUM-GRAINED
SAMPLING DATE	SL	9/17/2001	9/17/2001	9/17/2001
Endosulfan sulfate		1.6 U	2.1 U	1.9 U
Endrin		1.6 U	2.1 U	1.9 U
Endrin aldehyde		1.6 U	2.1 U	1.9 U
Endrin ketone		1.6 U	2.1 U	1.9 U
Heptachlor	10	1.6 U	2.1 U	1.9 U
Heptachlor epoxide		1.6 U	2.1 U	1.9 U
Methoxychlor		1.6 U	2.1 U	1.9 U
Toxaphene		76 U	110 U	93 U
alpha-BHC		1.6 U	2.1 U	1.9 U
alpha-Chlordane		1.6 U	2.1 U	1.9 U
beta-BHC		1.6 U	2.1 U	1.9 U
delta-BHC		1.6 U	2.1 U	1.9 U
gamma-BHC (Lindane)	10	1.6 U	2.1 U	1.9 U
gamma-Chlordane		1.6 U	2.1 U	1.9 U

Bold - Exceeds DMEF SL.
U - Not detected at the indicated method reporting limits (MRL).
J - Estimated concentration that is less than the MRL but greater than or equal to the MDL.
P - The GC or HPLC confirmation criteria were exceeded.